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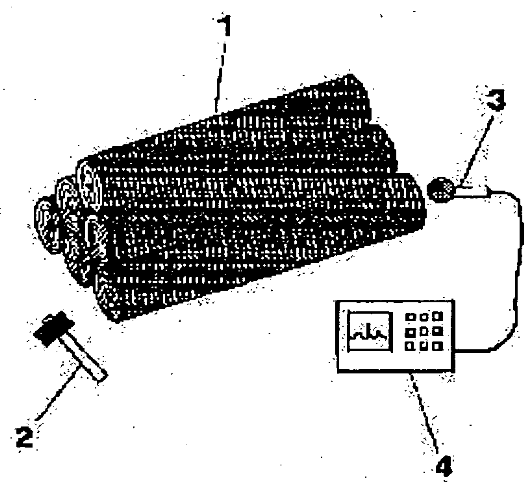
(54) SIMPLIFIED CLASSIFICATION OF SAWN WOOD ACCORDING TO GRADE

(57)Abstract:
PURPOSE: To simply classify the strength and static Young's modulus of sawn wood by using a natural oscillation frequency of a third order or higher even under a condition that the oscillation of a log is restricted.
CONSTITUTION: In a state that cut down logs 1 are left on the ground or that their oscillation is restricted such as in a state that they are heaped up as shown is the figure in a raw lumber market, that is to say, under a condition that the position of every node and every antinode of fundamental oscillations of the logs is restricted, longitudinal oscillation sounds generated when one edge of every log 1 is hit by a hammer 2 or the like are caught by a microphone 3 which is placed on the other edge. Then, in a simple classification method, a natural oscillation frequency of a third order or higher out of resonance frequencies obtained by analyzing the frequency by an FET(Fast Fourier Transformation) spectrum analyzer 4 is adopted, and the strength and static Young's modulus of sawn wood are estimated.



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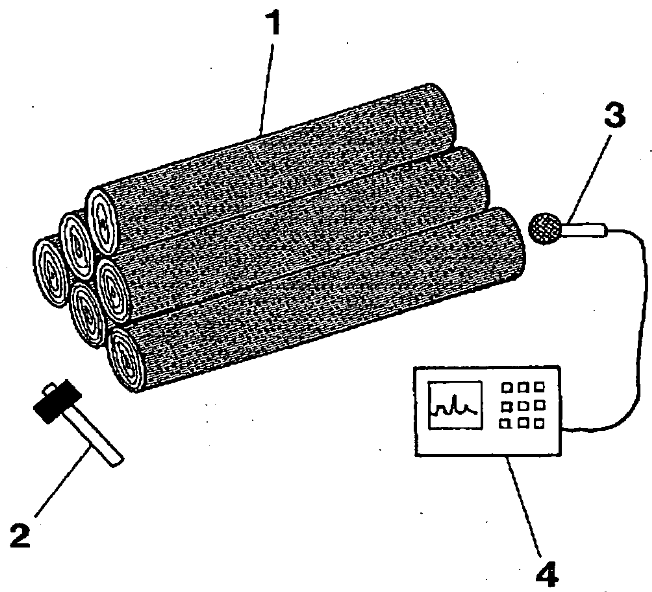

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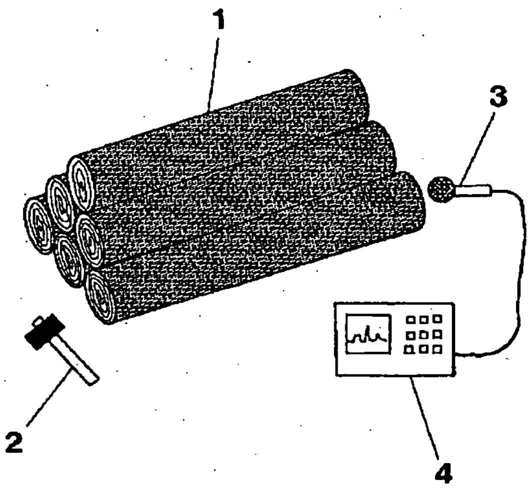

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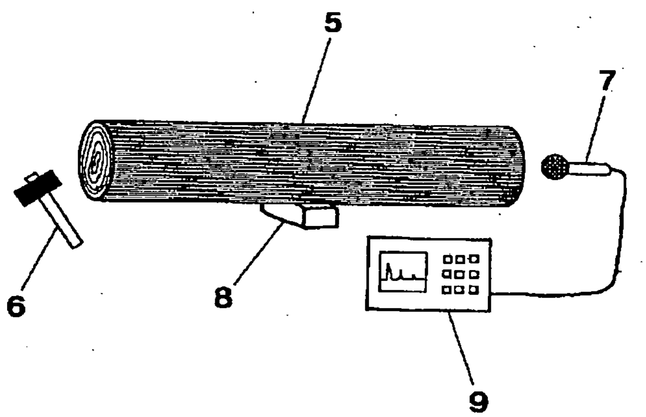

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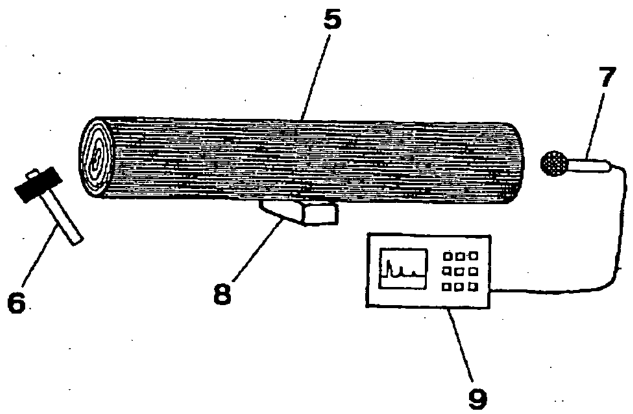

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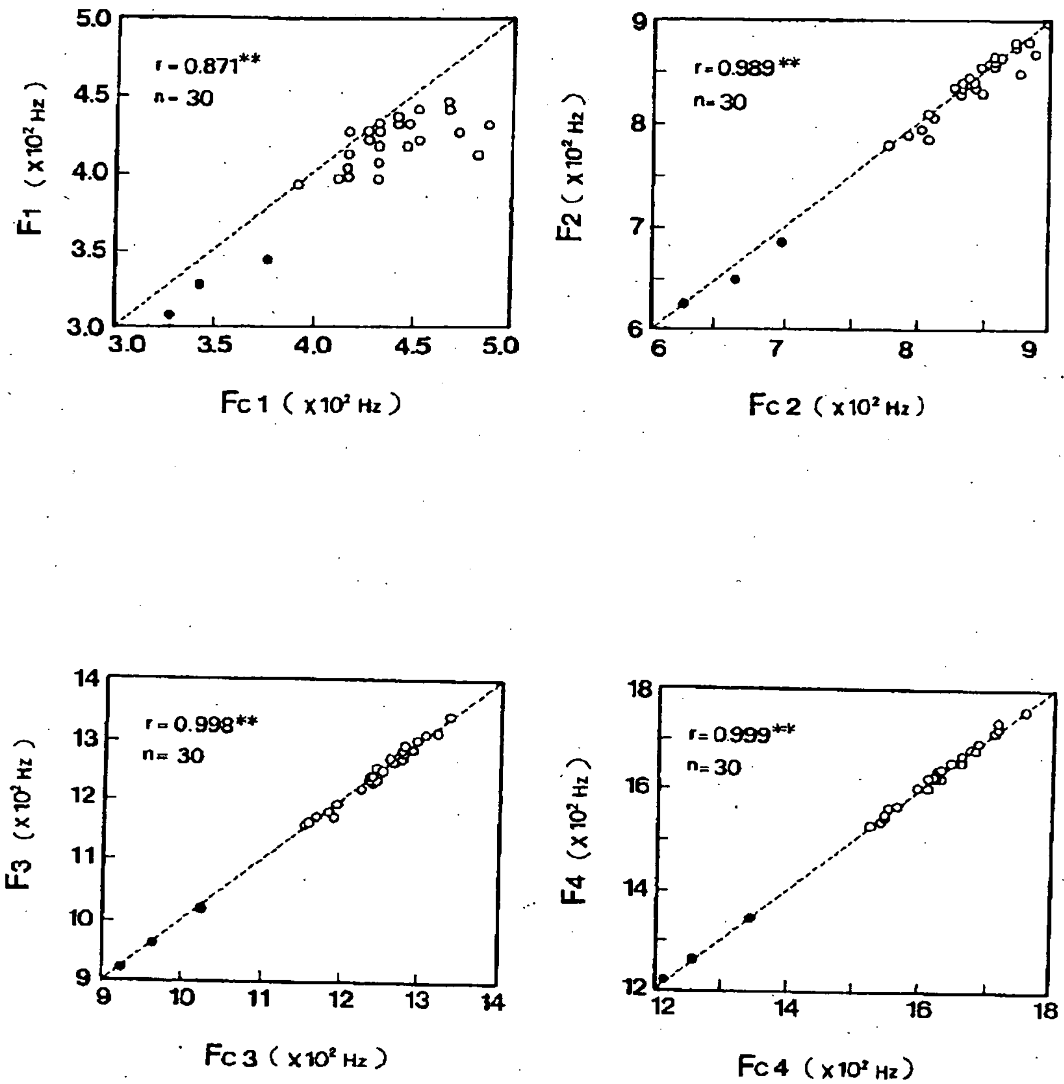

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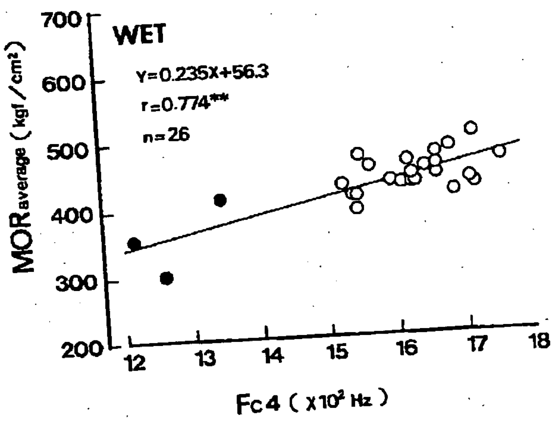
Drawing selection drawing 4



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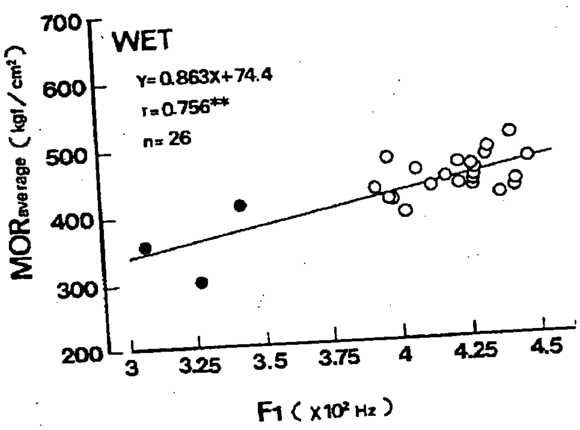

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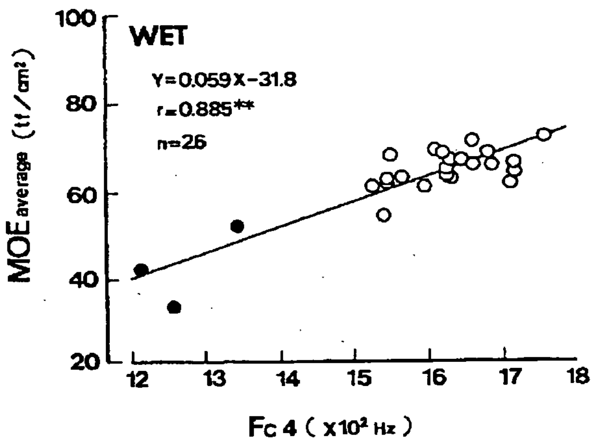

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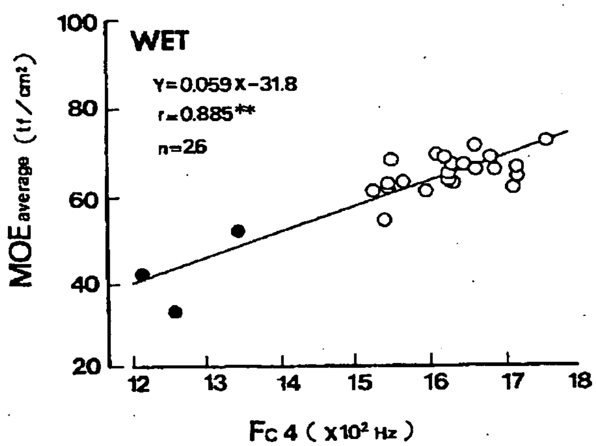

[Translation done.]

CLAIMS

[Claim(s)]

[Claim 1] After catching longitudinal-oscillation sound with the microphone (3) which hit the end side of a log with the hammer etc. (2), and was put on the other end side, By carrying out frequency analysis by the FFT (Fast FourierTransformation) spectrum analyzer (4), and using the 3rd more than resonant frequency among the resonance frequency obtained by it The simple grading method of the lumber article characterized by carrying out grading of the intensity and the static Young's modulus of a lumber article after being sawed up from the log.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the simple grading method of a lumber article of having used the 3rd more than resonant frequency in the state where especially vibration of a log was restrained, about the intensity of the lumber article using the resonance frequency obtained from the blow sound of a log, and the grading method of a static Young's modulus.
[0002]
[Description of the Prior Art] In order to aim at proper use of wood in recent years, it came to be called element indispensable to improvement in the yield, or performance maintenance of a product to perform the partition according to use in the stage of a log. against the background of this, the method of presuming the static Young's modulus of a lumber article is examined from the longitudinal-oscillation Young's modulus of the log called for by several 1 (Shizuoka laminate lumber Semiconductor Equipment & Materials International: -- manufacture and its on-the-strength performance of the large cross-section laminate lumber for structures using the Japan cedar from Shizuoka Prefecture --) 1988, the collection 1991 of the p.1-32, and three Nakamura **** : 41st Japan Wood Research Society convention summaries, p.100, the collection 1991 of the three : 41st Japan Wood Research Society convention summaries besides the Hishida ****, p.96.
[0003]
[Equation 1]

$$Et=4L^2f^2\rho/g$$

The longitudinal-oscillation Young's modulus which is Et:log here, the length of L:log, the primary resonant frequency of f:log, density of rho:log, g: Gravitational acceleration.
[0004] However, by this method, since it is necessary to use the primary resonant frequency of a log, as shown in drawing 2 , you have to support the portion of the paragraph of the fundamental vibration of a log, so that vibration may not be restrained. And it is quite serious work also from a weight, a diameter, and length of member needing to be measured. On the other hand, when [to reduce a parameter on the spot] it is in within the limits with the size of a log, a weight, and dryness from an idea that there may also be a partition which does not require precision so much There is an example which showed clearly experimentally that a static bending Young's modulus can be presumed in a fixed precision only from a primary resonant frequency (four person: "material" besides the Arima **** the 39th volume). the No. 444, 1990, p.44-50, Maruyama rule **, and Arima ****:Showa Architectural Institute of Japan Kanto branch research report collection in the 62 fiscal year -- p.349-352 Although presumed precision is inferior a little compared with the method of presuming the static Young's modulus of a lumber article, from Et according to this method, since a parameter is cut down sharply, it becomes very simple. However, at the point using the primary resonant frequency of a log, it is the same as that of an above-mentioned method. Therefore, as shown in drawing 2 , it is necessary to center-support or ends support a log, and in order to measure this resonant frequency correctly, it is necessary to pay careful attention so that fundamental vibration of a log may not be restrained by hanging by the way all use a cushioning material for support or the method of measuring on a fork lift truck in

case it carries, and other hoists etc. In this case, in what has the heavy weight of a log, work is serious and the thing exceeding 300kg also turns into what has a great effort and great time from a certain thing.

[0005]

[Problem(s) to be Solved by the Invention] this invention needs no work for not restraining not only measurement of a weight, a diameter, and length of member but vibration which was mentioned above in view of the trouble of the aforementioned technology, but the intensity and the static Young's modulus of a lumber article presume only from the resonance frequency obtained from the blow sound of a log under the condition of all oscillating restraints, and the method of carrying out grading of the lumber article simply offers.

[0006]

[Means for Solving the Problem] According to this invention, such a purpose hits the end side of a log with a hammer etc. (2). By carrying out frequency analysis by the FFT spectrum analyzer (4), after catching longitudinal-oscillation sound with the microphone (3) put on the other end side, and using the 3rd more than resonant frequency among the resonance frequency obtained by it It is attained by carrying out grading of the intensity and the static Young's modulus of a lumber article after being sawed up from the log. this invention is especially effective in the bottom of the condition by which the fundamental vibration of a log was restrained like the log (1) of the ****** state in the bolt commercial scene which it is left on the ground after cutting into small pieces with the log after felling, or is shown in drawing 1 .

[0007] About the conditions of the log set as the object of presumption of the intensity after lumber, and a static Young's modulus, although tree species are not asked, it is desirable that it is **** as much as possible. Moreover, in order to be dependent on the length of **, for example, when carrying out grading of 3m material and the 4m material simultaneously, it is necessary to notice especially a resonant frequency about the relation between each resonant frequency and intensity, and a static Young's modulus completely differing. That is, when carrying out grading of the intensity and the static Young's modulus after lumber of a log, it is necessary to create another grading table in the length of a log beforehand.

[0008] The tool for exciting the longitudinal oscillation of a log is good anything, if a hammer, a mallet, and the other longitudinal-oscillation sound of fixed level can be produced. Moreover, since what is necessary is just the level on which the trigger circuit of a frequency counter operates, the strength of a blow is lightly hit to compensate for a setup of this level. In this case, if the position to hit needs to be surely the cross-section-of-wood side of a log and other fields (the angle and the side of a log) are hit in order to excite the longitudinal oscillation of a log, exact frequency spectrum cannot be obtained. Moreover, the primary about resonant frequency [6th] can be easily obtained by the method of carrying out frequency analysis by the FFT spectrum analyzer, after catching this longitudinal-oscillation sound with the microphone put on the other end side (this end face is sufficient depending on the case although it is desirable that it is an other end side as much as possible), and moving cursor on the displayed frequency spectrum.

[0009] In this invention, as shown in drawing 3 , more than with the 3rd resonant frequency, it discovered hardly being influenced by vibration of a restraint. Therefore, after being cut down, a resonant frequency is measurable, if the 3rd more than resonant frequency of a log is used in the state left on the slant face of a mountain, a truck, a bolt commercial scene under conveyance, etc. with high precision also with ************.

[0010] Although any non-destroying parameter is the same Presume intensity and a static Young's modulus more than from the 3rd resonant frequency of a log, and in carrying out grading The intensity and the static Young's modulus which carried out the strength test beforehand about the measurement size which can obtain a fixed confidence level, and were obtained from the result, In order to ask for the regression line more than between the 3rd resonant frequencies of the log beforehand measured before lumber and to guarantee the intensity or the static Young's-modulus minimum value according to rank corresponding to this resonant frequency based on it further, it is necessary to calculate 5% confidence limit value of minimums by the statistical method about each rank. What is necessary is to determine the number of partitions that the gap during the rank

of intensity or a static Young's modulus is obtained more than fixed on the basis of this value, and just to perform simple grading of a lumber article according to it after that.

[0011]

[Example] The example which investigated the influence of the oscillating restraint to primary - the 4th resonant frequency of a log is shown below. In addition, the FFT spectrum analyzer (4 9) used for the experiment is AD-3525 (the make of the other company is sufficient) of A, Inc. - and - day, and sample offering logs are 27 Japan cedars from Miyazaki Takaoka-cho, and three Japan cedars from Kushima-shi, Miyazaki (the diameter of a tip of 24.5-27.5cm, a length of 400cm).

[0012] The relation between primary - the 4th resonant frequency (Fc1-Fc4) of a log (1) when vibration is restrained by drawing 3 , and primary - the 4th resonant frequency [in / (5) / when the portion of the paragraph of the fundamental vibration of a log is supported so that vibration may not be restrained] (F1-F4) is shown. It turns out that this drawing to both correlation becomes so high that an oscillating degree becomes high, and the value with the especially almost same case where it is not restrained with the case where vibration is restrained in the 3rd resonant frequency [4th] is shown.

[0013] Therefore, even if it is a log in the state where vibration was restrained, it is thought possible by using the 3rd high order more than resonant frequency to predict the intensity and the static Young's modulus of a lumber article after lumber.

[0014] Based on the above-mentioned result, the 4th resonant frequency of the log which had vibration restrained is adopted as a non-destroying parameter, and the example which presumed the flexural strength and the static bending Young's modulus of a lumber article is explained in detail below. [0015] As mentioned above, intensity and a Young's modulus are presumed from the parameter which can be measured in un-destroying, and when carrying out grading, it is necessary to ask for the regression line between them. Then, it asks for the regression line between the 4th resonant frequencies of a log, the flexural strength of a lumber article, and the static bending Young'ses modulus which had vibration restrained, and the functionality between them is checked. In addition, a lumber size is 200cm in 3.6cm in width of face of 21cm, and thickness, and length.

[0016] The relation between the 4th resonant frequency (Fc4) of the log which had vibration restrained by drawing 4 , and the average flexural strength (MORaverage) classified by log of the lumber article sawed up from this log is shown. In this drawing, the relation between Fc4 and MORaverage has acquired high correlation at 1% of level of significance. Moreover, a relation with MORaverage is indicated to be the primary resonant frequency (F1) measured by the method of supporting the portion of the paragraph of the fundamental vibration of a log so that vibration may not be restrained to drawing 5 . The inclination of drawing 4 and drawing 5 is approximated very well, and the correlation coefficient in each drawing shows that four are the presumed index of matching MORaverage at FcF1.

[0017] The relation between Fc4 and the average static bending Young's modulus (MOEaverage) according to log of the lumber article sawed up from this log is shown in drawing 6 . In this drawing, the relation between Fc4 and MOEaverage has acquired high correlation at 1% of level of significance. Moreover, the relation between F1 and MOEaverage is shown in drawing 7 . The inclination of drawing 6 and drawing 7 is approximated very well, and the correlation coefficient in each drawing shows that four are the presumed index of matching MOEaverage at FcF1.

[0018] From the above result, it is judged that it is effective to presume the flexural strength and the static bending Young's modulus of a lumber article using Fc4. Then, the example which carried out grading of the flexural strength of a lumber article and a static bending Young's modulus is shown below by making Fc4 into a non-destroying parameter.

[0019] In order to guarantee the on-the-strength performance minimum value according to rank corresponding to the non-destroying parameter (here Fc4) divided into some ranks when performing grading to the on-the-strength performance value of wood as mentioned above, it is necessary to calculate 5% confidence limit value of minimums by the statistical method about each rank. Then, Fc4 is divided into six ranks, 5% confidence limit value of minimums of the flexural strength according to each rank and a static bending Young's modulus is computed by

several 2, and the example which carried out grading from the result is shown in Table 1 and 2.
[0020]
[Equation 2]
$$Yi=a+bxi-t\ (n-2,\ 0.05)\ \surd\ [\ \{1+1/n+\ (xi-x)\ ^{2}/sx\}\ Ve]$$

Each flexural strength here corresponding to xi:Fc4 and Yi:Fc4 or 5% confidence-limit value of minimums of a static bending Young's modulus, the average of x:Fc4, n:measurement size, Ve: Error variance.
[0021]
[Table 1]

Fc4	1300	1400	1500	1600	1700	1800
MOR下限値	302	329	354	378	400	422

[0022]
[Table 2]

Fc4	1300	1400	1500	1600	1700	1800
MOE下限値	35	41	47	53	59	65

[0023] From Table 1 and 2, 5% confidence limit value (in front Naka, it was described as the MOR lower limit and the MOE lower limit, respectively) of minimums of flexural strength and a static bending Young's modulus shows the very clear difference between each rank. Therefore, when adopting Fc4 as a non-destroying parameter and carrying out grading of flexural strength and the static bending Young's modulus, it is judged as a thing classifiable into about at least six grades.
[0024]
[Effect of the Invention] Thus, according to this invention, it is left on the ground after cutting into small pieces with the log after felling. Or even if it is under all the conditions by which the paragraph of the fundamental vibration in the state, i.e., a log, where vibration was restrained like the ****** state in a bolt commercial scene etc., and the position of a belly were restrained It is possible by carrying out [sound / longitudinal-oscillation / of a log] frequency analysis to predict the intensity and the static Young's modulus of a lumber article after being sawed up by adopting the 3rd / at least / resonant frequency among the resonance frequency obtained. In this case, since it is not necessary to support the portion of the paragraph of the fundamental vibration of a log in the case of measurement, the work which carries out one log at a time, the work which covers the bottom of a log with a cushioning material become unnecessary, and the effort and time which work takes are mitigated sharply.

[Translation done.]

PRIOR ART

[Description of the Prior Art] In order to aim at proper use of wood in recent years, it came to be called element indispensable to improvement in the yield, or performance maintenance of a product to perform the partition according to use in the stage of a log. against the background of this, the method of presuming the static Young's modulus of a lumber article is examined from the longitudinal-oscillation Young's modulus of the log called for by several 1 (Shizuoka laminate lumber Semiconductor Equipment & Materials International: -- manufacture and its on-the-strength performance of the large cross-section laminate lumber for structures using the Japan cedar from Shizuoka Prefecture --) 1988, the collection 1991 of the p.1-32, and three Nakamura **** : 41st Japan Wood Research Society convention summaries, p.100, the collection 1991 of the three : 41st Japan Wood Research Society convention summaries besides the Hishida ****, p.96.

[0003]

[Equation 1]

$$Et=4L^2f^2\rho/g$$

The longitudinal-oscillation Young's modulus which is Et:log here, the length of L:log, the primary resonant frequency of f:log, density of rho:log, g: Gravitational acceleration.

[0004] However, by this method, since it is necessary to use the primary resonant frequency of a log, as shown in drawing 2 , you have to support the portion of the paragraph of the fundamental vibration of a log, so that vibration may not be restrained. And it is quite serious work also from a weight, a diameter, and length of member needing to be measured. On the other hand, when [to reduce a parameter on the spot] it is in within the limits with the size of a log, a weight, and dryness from an idea that there may also be a partition which does not require precision so much There is an example which showed clearly experimentally that a static bending Young's modulus can be presumed in a fixed precision only from a primary resonant frequency (four person: "material" besides the Arima **** the 39th volume). the No. 444, 1990, p.44-50, Maruyama rule **, and Arima ****:Showa Architectural Institute of Japan Kanto branch research report collection in the 62 fiscal year -- p.349-352 Although presumed precision is inferior a little compared with the method of presuming the static Young's modulus of a lumber article, from Et according to this method, since a parameter is cut down sharply, it becomes very simple. However, at the point using the primary resonant frequency of a log, it is the same as that of an above-mentioned method. Therefore, as shown in drawing 2 , it is necessary to center-support or ends support a log, and in order to measure this resonant frequency correctly, it is necessary to pay careful attention so that fundamental vibration of a log may not be restrained by hanging by the way all use a cushioning material for support or the method of measuring on a fork lift truck in case it carries, and other hoists etc. In this case, in what has the heavy weight of a log, work is serious and the thing exceeding 300kg also turns into what has a great effort and great time from a certain thing.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] this invention relates to the simple grading method of a lumber article of having used the 3rd more than resonant frequency in the state where especially vibration of a log was restrained, about the intensity of the lumber article using the resonance frequency obtained from the blow sound of a log, and the grading method of a static Young's modulus.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Thus, in this invention, it is left on the ground after cutting into small pieces with the log after felling, or even if it is under all the conditions by which the paragraph of the fundamental vibration in the state, i.e., a log, where vibration was restrained like the ****** state in a bolt commercial scene etc., and the position of a belly were restrained, the 3rd [at least] resonant frequency is adopted among the resonance frequency obtained by carrying out [sound / longitudinal-oscillation / of a log] frequency analysis. Therefore, it is possible to predict the intensity and the static Young's modulus of a lumber article after being sawed up. In this case, since it is not necessary to support the portion of the paragraph of the fundamental vibration of a log in the case of measurement, the work which carries out one log at a time, the work which covers the bottom of a log with a cushioning material become unnecessary, and the effort and time which work takes are mitigated sharply.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] this invention needs no work for not restraining not only measurement of a weight, a diameter, and length of member but vibration which was mentioned above in view of the trouble of the aforementioned technology, but the intensity and the static Young's modulus of a lumber article presume only from the resonance frequency obtained from the blow sound of a log under the condition of all oscillating restraints, and the method of carrying out grading of the lumber article simply offers.

[Translation done.]

MEANS

[Means for Solving the Problem] According to this invention, such a purpose hits the end side of a log with a hammer etc. (2). By carrying out frequency analysis by the FFT spectrum analyzer (4), after catching longitudinal-oscillation sound with the microphone (3) put on the other end side, and using the 3rd more than resonant frequency among the resonance frequency obtained by it It is attained by carrying out grading of the intensity and the static Young's modulus of a lumber article after being sawed up from the log. this invention is especially effective in the bottom of the condition by which the fundamental vibration of a log was restrained like the log (1) of the ****** state in the bolt commercial scene which it is left on the ground after cutting into small pieces with the log after felling, or is shown in drawing 1 .
[0007] About the conditions of the log set as the object of presumption of the intensity after lumber, and a static Young's modulus, although tree species are not asked, it is desirable that it is **** as much as possible. Moreover, in order to be dependent on the length of **, for example, when carrying out grading of 3m material and the 4m material simultaneously, it is necessary to notice especially a resonant frequency about the relation between each resonant frequency and intensity, and a static Young's modulus completely differing. That is, when carrying out grading of the intensity and the static Young's modulus after lumber of a log, it is necessary to create another grading table in the length of a log beforehand.
[0008] The tool for exciting the longitudinal oscillation of a log is good anything, if a hammer, a mallet, and the other longitudinal-oscillation sound of fixed level can be produced. Moreover, since what is necessary is just the level on which the trigger circuit of a frequency counter operates, the strength of a blow is lightly hit to compensate for a setup of this level. In this case, if the position to hit needs to be surely the cross-section-of-wood side of a log and other fields (the angle and the side of a log) are hit in order to excite the longitudinal oscillation of a log, exact frequency spectrum cannot be obtained. Moreover, the primary about resonant frequency [6th] can be easily obtained by the method of carrying out frequency analysis by the FFT spectrum analyzer, after catching this longitudinal-oscillation sound with the microphone put on the other end side (this end face is sufficient depending on the case although it is desirable that it is an other end side as much as possible), and moving cursor on the displayed frequency spectrum.
[0009] In this invention, as shown in drawing 3 , more than with the 3rd resonant frequency, it discovered hardly being influenced by vibration of a restraint. Therefore, after being cut down, a resonant frequency is measurable, if the 3rd more than resonant frequency of a log is used in the state left on the slant face of a mountain, a truck, a bolt commercial scene under conveyance, etc. with high precision also with ************.
[0010] Although any non-destroying parameter is the same Presume intensity and a static Young's modulus more than from the 3rd resonant frequency of a log, and in carrying out grading The intensity and the static Young's modulus which carried out the strength test beforehand about the measurement size which can obtain a fixed confidence level, and were obtained from the result, In order to ask for the regression line more than between the 3rd resonant frequencies of the log beforehand measured before lumber and to guarantee the intensity or the static Young's-modulus minimum value according to rank corresponding to this resonant frequency based on it further, it is necessary to calculate 5% confidence limit value of minimums by the statistical method about each rank. What is necessary is to determine the number of partitions that the gap during the rank

of intensity or a static Young's modulus is obtained more than fixed on the basis of this value, and just to perform simple grading of a lumber article according to it after that.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EXAMPLE

[Example] The example which investigated the influence of the oscillating restraint to primary - the 4th resonant frequency of a log is shown below. In addition, the FFT spectrum analyzer (4 9) used for the experiment is AD-3525 (the make of the other company is sufficient) of A, Inc. - and - day, and sample offering logs are 27 Japan cedars from Miyazaki Takaoka-cho, and three Japan cedars from Kushima-shi, Miyazaki (the diameter of a tip of 24.5-27.5cm, a length of 400cm).
[0012] The relation between primary - the 4th resonant frequency (Fc1-Fc4) of a log (1) when vibration is restrained by drawing 3 , and primary - the 4th resonant frequency [in / (5) / when the portion of the paragraph of the fundamental vibration of a log is supported so that vibration may not be restrained] (F1-F4) is shown. It turns out that this drawing to both correlation becomes so high that an oscillating degree becomes high, and the value with the especially almost same case where it is not restrained with the case where vibration is restrained in the 3rd resonant frequency [4th] is shown.
[0013] Therefore, even if it is a log in the state where vibration was restrained, it is thought possible by using the 3rd high order more than resonant frequency to predict the intensity and the static Young's modulus of a lumber article after lumber.
[0014] Based on the above-mentioned result, the 4th resonant frequency of the log which had vibration restrained is adopted as a non-destroying parameter, and the example which presumed the flexural strength and the static bending Young's modulus of a lumber article is explained in detail below. [0015] As mentioned above, intensity and a Young's modulus are presumed from the parameter which can be measured in un-destroying, and when carrying out grading, it is necessary to ask for the regression line between them. Then, it asks for the regression line between the 4th resonant frequencies of a log, the flexural strength of a lumber article, and the static bending Young'ses modulus which had vibration restrained, and the functionality between them is checked. In addition, a lumber size is 200cm in 3.6cm in width of face of 21cm, and thickness, and length.
[0016] The relation between the 4th resonant frequency (Fc4) of the log which had vibration restrained by drawing 4 , and the average flexural strength (MORaverage) classified by log of the lumber article sawed up from this log is shown. In this drawing, the relation between Fc4 and MORaverage has acquired high correlation at 1% of level of significance. Moreover, a relation with MORaverage is indicated to be the primary resonant frequency (F1) measured by the method of supporting the portion of the paragraph of the fundamental vibration of a log so that vibration may not be restrained to drawing 5 . The inclination of drawing 4 and drawing 5 is approximated very well, and the correlation coefficient in each drawing shows that four are the presumed index of matching MORaverage at FcF1.
[0017] The relation between Fc4 and the average static bending Young's modulus (MOEaverage) according to log of the lumber article sawed up from this log is shown in drawing 6 . In this drawing, the relation between Fc4 and MOEaverage has acquired high correlation at 1% of level of significance. Moreover, the relation between F1 and MOEaverage is shown in drawing 7 . The inclination of drawing 6 and drawing 7 is approximated very well, and the correlation coefficient in each drawing shows that four are the presumed index of matching MOEaverage at FcF1.
[0018] From the above result, it is judged that it is effective to presume the flexural strength and the static bending Young's modulus of a lumber article using Fc4. Then, the example which

carried out grading of the flexural strength of a lumber article and a static bending Young's modulus is shown below by making Fc4 into a non-destroying parameter.

[0019] In order to guarantee the on-the-strength performance minimum value according to rank corresponding to the non-destroying parameter (here Fc4) divided into some ranks when performing grading to the on-the-strength performance value of wood as mentioned above, it is necessary to calculate 5% confidence limit value of minimums by the statistical method about each rank. Then, Fc4 is divided into six ranks, 5% confidence limit value of minimums of the flexural strength according to each rank and a static bending Young's modulus is computed by several 2, and the example which carried out grading from the result is shown in Table 1 and 2.

[0020]

[Equation 2]

$$Yi=a+bxi-t\ (n-2,\ 0.05)\ \sqrt{\ [\ \{1+1/n+\ (xi-x)\ ^2/sx\}\ Ve]}$$

Each flexural strength here corresponding to xi:Fc4 and Yi:Fc4 or 5% confidence-limit value of minimums of a static bending Young's modulus, the average of x:Fc4, n:measurement size, Ve: Error variance.

[0021]

[Table 1]

Ｆｃ４	1300	1400	1500	1600	1700	1800
ＭＯＲ下限値	３０２	３２９	３５４	３７８	４００	４２２

[0022]

[Table 2]

Ｆｃ４	1300	1400	1500	1600	1700	1800
ＭＯＥ下限値	３５	４１	４７	５３	５９	６５

[0023] From Table 1 and 2, 5% confidence limit value (in front Naka, it was described as the MOR lower limit and the MOE lower limit, respectively) of minimums of flexural strength and a static bending Young's modulus shows the very clear difference between each rank. Therefore, when adopting Fc4 as a non-destroying parameter and carrying out grading of flexural strength and the static bending Young's modulus, it is judged as a thing classifiable into about at least six grades.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the perspective diagram showing the measuring method of the resonant frequency of the log by the longitudinal-oscillation sound in the state where vibration was restrained.

[Drawing 2] As vibration is not restrained, it is the perspective diagram showing the measuring method of the resonant frequency of the log by the longitudinal-oscillation sound in the state where the portion of the paragraph of fundamental vibration was supported.

[Drawing 3] It is the relation between primary - the 4th resonant frequency (Fc1-Fc4) of the log which had vibration restrained, and primary - the 4th resonant frequency (F1-F4) in the state where the portion of the paragraph of the fundamental vibration of a log was supported so that vibration might not be restrained.

[Drawing 4] It is the relation between Fc4 and the average flexural strength (MORaverage) classified by log of the lumber article (width of face of 21cm, the thickness of 3.6cm, a length of 200cm) sawed up from this log.

[Drawing 5] It is the relation between F1 and MORaverage.

[Drawing 6] It is the relation between Fc4 and the average static bending Young's modulus (MOEaverage) according to log of the lumber article sawed up from this log.

[Drawing 7] It is the relation between F1 and MOEaverage.

[Description of Notations]

1 Five Log
2 Six Hammer
3 Seven Microphone
8 Cushioning materials (rubber, tire of an automobile, etc.)
4 Nine FFT spectrum analyzer

[Translation done.]

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ABSTRACT:

PURPOSE: To simply classify the strength and static Young's modulus of sawn wood by using a natural oscillation frequency of a third order or higher even under a condition that the oscillation of a log is restricted.

CONSTITUTION: In a state that cut down logs 1 are left on the ground or that their oscillation is restricted such as in a state that they are heaped up as shown is the figure in a raw lumber market, that is to say, under a condition that the position of every node and every antinode of fundamental oscillations of the logs is restricted, longitudinal oscillation sounds generated when one edge of every log 1 is hit by a hammer 2 or the like are caught by a microphone 3 which is placed on the other edge. Then, in a simple

classification method,
a natural oscillation frequency of a third order or higher out of resonance
frequencies obtained by analyzing the frequency by an FET(Fast Fourier
Transformation) spectrum analyzer 4 is adopted, and the strength and static
Young's modulus of sawn wood are estimated.

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審査請求　未請求　請求項の数１　ＦＤ　（全　６　頁）

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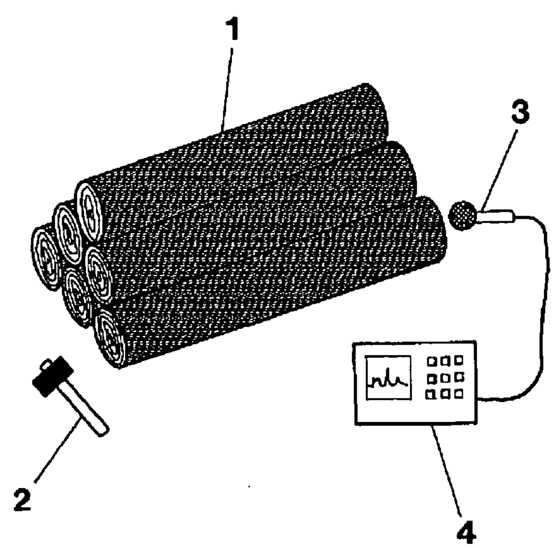
(54)【発明の名称】　製材品の簡易等級区分方法

(57)【要約】
【目的】　丸太の振動が拘束された条件下であっても、３次以上の固有振動数を用いることにより、製材品の強度及び静的ヤング係数の簡易な等級区分を可能とする。
【構成】　伐採後の丸太で、地面に放置され、あるいは原木市場における椪積み状態等のように振動を拘束された状態、すなわち丸太の基本振動の節及び腹の位置が拘束されたあらゆる条件下において、丸太の一端面をハンマー等で打撃したときに生じる縦振動音を、他端面に置いたマイクロフォンでキャッチし、ＦＦＴ（Fast Fourier Transformation）スペクトルアナライザによって周波数分析することによって得られる共振周波数のうち、３次以上の固有振動数を採用することによって、製材品の強度及び静的ヤング係数を推定する簡易な等級区分方法。



【特許請求の範囲】

【請求項1】　丸太の一端面をハンマーなどで打撃（２）し、他端面に置いたマイクロフォン（３）で縦振動音をキャッチしたうえ、ＦＦＴ（Fast FourierTransformation）スペクトルアナライザ（４）によって周波数分析し、それによって得られる共振周波数のうち３次以上の固有振動数を用いることにより、丸太から製材された後の製材品の強度及び静的ヤング係数を等級区分することを特徴とする製材品の簡易等級区分方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、丸太の打撃音から得られる共振周波数を用いた製材品の強度及び静的ヤング係数の等級区分方法に関し、特に丸太の振動が拘束された状態における３次以上の固有振動数を利用した製材品の簡易等級区分方法に関する。

【０００２】

【従来の技術】近年、木材の適正利用をはかるために、丸太の段階で用途別区分を行うことが歩留まりの向上や製品の性能保持に不可欠な要素と言われるようになった。これを背景に、数１で求められる丸太の縦振動ヤング係数から、製材品の静的ヤング係数を推定する方法が検討されている（静岡県集成材工業会：静岡県産スギを用いた構造用大断面集成材の製造とその強度性能、１９８８、ｐ．１～３２，中村昇他３名：第４１回日本木材学会大会要旨集１９９１、ｐ．１００，菱田重寿他３名：第４１回日本木材学会大会要旨集１９９１、ｐ．９６）。

【０００３】

【数１】

$$Et=4L^2f^2\rho/g$$

ここで、Ｅｔ:丸太の縦振動ヤング係数、Ｌ:丸太の長さ、ｆ:丸太の１次固有振動数、ρ:丸太の密度、ｇ:重力加速度。

【０００４】しかし、この方法では、丸太の１次固有振動数を用いる必要があるため、振動を拘束しないように、図２に示すように丸太の基本振動の節の部分を支えなければならない。しかも、重量、直径、及び材長の測定も必要なことから、かなり大変な作業である。一方、現場では測定項目を減らしたいときや、それほど精度を要求しない区分もありうるとの考えから、丸太の寸法、重量、及び乾燥状態がある範囲内にあるときには、１次固有振動数のみからでも一定の精度で静的曲げヤング係数を推定できることを実験的に明らかにした例がある（有馬孝禮他４名：「材料」第３９巻、第４４４号、１９９０、ｐ．４４～５０，丸山則議、有馬孝禮：昭和６２年度日本建築学会関東支部研究報告集ｐ．３４９～３５２）。この方法によれば、Ｅｔから製材品の静的ヤング係数を推定する方法に比べて若干推定精度が劣るものの、測定項目が大幅に削減されるため、極めて簡易になる。ただし、丸太の１次固有振動数を用いる点では上述の方法と同様である。したがって、同固有振動数を正確に計測するために、図２に示すように丸太を中央支持、または両端支持し、いずれも支持物にクッション材を用いる方法、あるいは運搬する際にフォークリフト上で計測する方法、その他ホイストで吊り下げる等の方法等で丸太の基本振動を拘束しないように細心の注意を払う必要がある。この場合、丸太の重量は重いものでは３００ｋｇを越えるものもあることから、作業は大変であり、労力や時間は多大なものとなる。

【０００５】

【発明が解決しようとする課題】本発明は、前記技術の問題点に鑑み、重量、直径及び材長の測定のみならず、前述したような振動を拘束しないための全ての作業を必要とせず、あらゆる振動拘束の条件下において、丸太の打撃音から得られる共振周波数のみから製材品の強度及び静的ヤング係数を推定し、製材品を簡易に等級区分する方法を提供するものである。

【０００６】

【課題を解決するための手段】このような目的は、本発明によれば、丸太の一端面をハンマー等で打撃（２）し、他端面に置いたマイクロフォン（３）で縦振動音をキャッチしたうえ、ＦＦＴスペクトルアナライザ（４）によって周波数分析し、それによって得られる共振周波数のうち３次以上の固有振動数を用いることにより、丸太から製材された後の製材品の強度及び静的ヤング係数を等級区分することによって達成される。本発明は、伐採後の丸太で玉切り後地面に放置され、あるいは図１に示す原木市場における椪積み状態の丸太（１）等のように、丸太の基本振動が拘束された条件下において特に有効である。

【０００７】製材後の強度及び静的ヤング係数の推定の対象となる丸太の条件については、樹種は問わないが、出来るだけ通直であることが望ましい。また、固有振動数は、特に材の長さに依存するため、例えば同時に３ｍ材と４ｍ材を等級区分する場合、それぞれの固有振動数と強度及び静的ヤング係数との関係が全く異なることに注意する必要がある。つまり、丸太の製材後の強度及び静的ヤング係数を等級区分する場合には、予め、丸太の長さ別の等級区分表を作成しておく必要がある。

【０００８】丸太の縦振動を励起するための道具は、金槌、木槌、その他一定レベルの縦振動音を生じさせることが出来るものであれば何でも良い。また、打撃の強弱は、周波数カウンタのトリガ回路が作動するレベルであれば良いので、同レベルの設定に合わせて軽く打撃する。この場合、丸太の縦振動を励起するために、打撃する位置は必ず丸太の木口面であることが必要であり、他の面（丸太の角や側面）を打撃すると正確な周波数スペクトルを得ることは出来ない。また、他端面（出来るだけ他端面であることが望ましいが場合によっては同端面

3

でも良い）に置いたマイクロフォンによりこの縦振動音をキャッチしたうえ、ＦＦＴスペクトルアナライザによって周波数分析し、表示された周波数スペクトル上でカーソルを移動する等の方法により、容易に１次ないし６次程度の固有振動数を得ることが出来る。

【０００９】本発明においては、図3に示すように、３次以上の固有振動数では振動の拘束の影響を殆ど受けないことを発見した。したがって、丸太の３次以上の固有振動数を用いれば、伐採された後、山の斜面に放置された状態、または運搬中のトラックや原木市場等で椪積みの状態のままでも、高精度に固有振動数を計測することが出来る。

【００１０】いずれの非破壊パラメータも同様であるが、丸太の３次以上の固有振動数から強度や静的ヤング係数を推定し、等級区分する場合には、一定の信頼水準を得られるサンプル数について予め強度試験を実施し、その結果から得られた強度及び静的ヤング係数と、予め製材前に測定した丸太の３次以上の固有振動数との間の回帰直線を求め、さらにそれを基にして同固有振動数に対応するランク別の強度または静的ヤング係数最低値を保証するために、各ランクについて統計的手法により下限５％信頼限界値を求める必要がある。この値を基準にして、強度または静的ヤング係数のランク間の格差が一定以上得られるように区分数を決定し、その後はそれに従って製材品の簡易等級区分を行えば良い。

【００１１】

【実施例】丸太の１次～４次固有振動数に対する振動拘束の影響を調べた例を以下に示す。なお、実験に使用したＦＦＴスペクトルアナライザ（４、９）は、株式会社エー･アンド･デイのＡＤ－３５２５（他社製でもかまわない）で、供試丸太は宮崎県高岡町産スギ２７本､宮崎県串間市産スギ３本（末口径２４.５～２７.５ｃｍ､長さ４００ｃｍ）である。

【００１２】図3に、振動を拘束された場合における丸太（１）の1次～４次固有振動数（Ｆｃ１～Ｆｃ４）と、振動を拘束しないように丸太の基本振動の節の部分を支えた場合（５）における１次～４次固有振動数（Ｆ１～Ｆ４）との関係を示す。同図から、両者の相関は、振動次数が高くなるほど高くなり、特に３次、４次固有振動数では、振動を拘束された場合と拘束されない場合がほぼ同一の値を示していることが分かる。

【００１３】したがって、振動が拘束された状態の丸太であっても、３次以上の高次固有振動数を用いることにより、製材後の製材品の強度及び静的ヤング係数を予測することが可能と考えられる。

【００１４】上記の結果を踏まえて、振動を拘束された丸太の４次固有振動数を非破壊パラメータとして採用し、製材品の曲げ強度と静的曲げヤング係数を推定した例を以下に詳しく説明する。

4

【００１５】前述したように、非破壊的に測定できるパラメータから強度やヤング係数を推定し、等級区分する場合には、それらの間の回帰直線を求める必要がある。そこで、振動を拘束された丸太の４次固有振動数と製材品の曲げ強度及び静的曲げヤング係数との間の回帰直線を求め、それらの間の相関性を確認する。なお、製材寸法は幅２１ｃｍ、厚さ３．６ｃｍ、長さ２００ｃｍである。

【００１６】図4に振動を拘束された丸太の４次固有振動数（Ｆｃ４）と、同丸太から製材された製材品の丸太別平均曲げ強度（ＭＯＲaverage）との関係を示す｡同図において、Ｆｃ４とＭＯＲaverageとの関係は、危険率1％で高い相関を得ている。また、図5に振動を拘束しないように丸太の基本振動の節の部分を支える方法で測定した１次固有振動数（Ｆ１）と､ＭＯＲaverageとの関係を示す。図４と図５の傾向は非常に良く近似しており、それぞれの図中の相関係数から、Ｆｃ４はＦ１に匹敵するＭＯＲaverageの推定指標であることが分かる。

【００１７】図6にＦｃ４と、同丸太から製材された製材品の丸太別平均静的曲げヤング係数（ＭＯＥaverage）との関係を示す。同図において、Ｆｃ４とＭＯＥaverageとの関係は、危険率１％で高い相関を得ている。また､図７にＦ１とＭＯＥaverageとの関係を示す。図6と図７の傾向は､非常に良く近似しており､それぞれの図中の相関係数から､Ｆｃ４はＦ１に匹敵するＭＯＥaverageの推定指標であることが分かる。

【００１８】以上の結果から、Ｆｃ４を用いて製材品の曲げ強度や静的曲げヤング係数を推定することは有効と判断される。そこで、Ｆｃ４を非破壊パラメータとして、製材品の曲げ強度及び静的曲げヤング係数の等級区分を実施した例を以下に示す。

【００１９】前述したように、木材の強度性能値に対して等級区分を行う場合、いくつかのランクに分けられた非破壊パラメータ（ここではＦｃ４）に対応するランク別の強度性能最低値を保証するために、各ランクについて統計的手法により下限５％信頼限界値を求める必要がある。そこで、Ｆｃ４を６つのランクに分けて、数２により各ランク別の曲げ強度と静的曲げヤング係数の下限５％信頼限界値を算出し、その結果から等級区分を実施した例を表１及び表２に示す。

【００２０】

【数２】

$$Yi=a+bxi-t\ (n-2,\ 0.05)\ \sqrt{\ [\ \{1+1/n+\ (xi-x)\ ^2/sx\}\ Ve]}$$

ここで、xi:Ｆｃ４、Yi:Ｆｃ４に対応する個々の曲げ強度または静的曲げヤング係数の下限５％信頼限界値、x:Ｆｃ４の平均値、n:サンプル数、Ve:誤差分散。

【００２１】

【表１】

Fc4	1300	1400	1500	1600	1700	1800
MOR下限値	302	329	354	378	400	422

【0022】

【表2】

Fc4	1300	1400	1500	1600	1700	1800
MOE下限値	35	41	47	53	59	65

【0023】表1及び表2から、曲げ強度及び静的曲げヤング係数の下限5％信頼限界値（表中ではそれぞれMOR下限値、MOE下限値と記した）は、各ランク間で非常に明確な差を示している。したがって、非破壊パラメータとしてFc4を採用し、曲げ強度と静的曲げヤング係数を等級区分する場合、少なくとも6等級程度には区分出来るものと判断される。

【0024】

【発明の効果】このように本発明によれば、伐採後の丸太で玉切り後地面に放置され、あるいは原木市場等における椪積み状態等のように振動を拘束された状態、すなわち丸太の基本振動の節及び腹の位置が拘束されたあらゆる条件下であっても、丸太の縦振動音を周波数分析することによって得られる共振周波数のうち、少なくとも3次の固有振動数を採用することにより、製材された後の製材品の強度及び静的ヤング係数を予測することが可能である。この場合、測定の際に丸太の基本振動の節の部分を支える必要がないため、丸太を一本ずつ運び出す作業や丸太の下にクッション材を敷く作業などが不要となり、作業に要する労力や時間が大幅に軽減される。

【図面の簡単な説明】

【図1】振動を拘束された状態での縦振動音による丸太の固有振動数の測定方法を示す斜視図である。

【図2】振動を拘束しないように、基本振動の節の部分を支えた状態での縦振動音による丸太の固有振動数の測定方法を示す斜視図である。

【図3】振動を拘束された丸太の1次～4次固有振動数（Fc1～Fc4）と、振動を拘束しないように丸太の基本振動の節の部分を支えた状態における1次～4次固有振動数（F1～F4）との関係である。

【図4】Fc4と同丸太から製材された製材品（幅21cm、厚さ3.6cm、長さ200cm）の丸太別平均曲げ強度（MORaverage）との関係である。

【図5】F1とMORaverageとの関係である。

【図6】Fc4と同丸太から製材された製材品の丸太別平均静的曲げヤング係数（MOEaverage）との関係である。

【図7】F1とMOEaverageとの関係である。

【符号の説明】

1、5　丸太

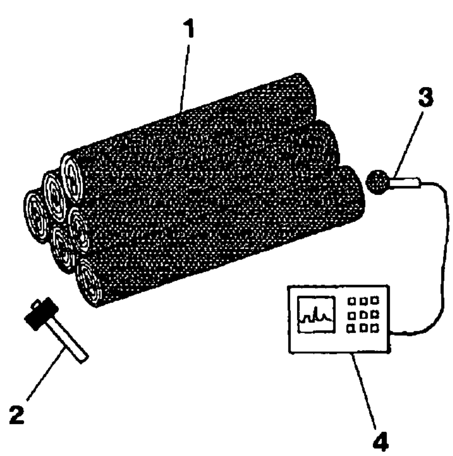
2、6　ハンマー

3、7　マイクロフォン

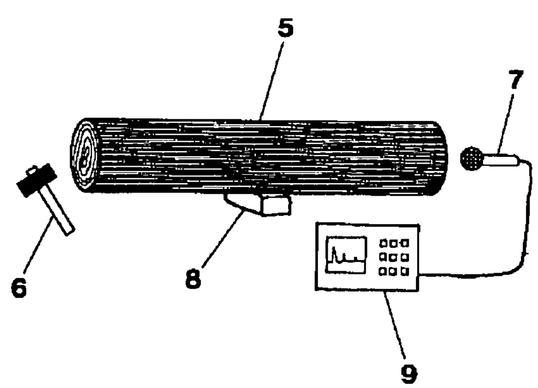
8、クッション材（ゴム、自動車のタイヤなど）

4、9　FFTスペクトルアナライザ

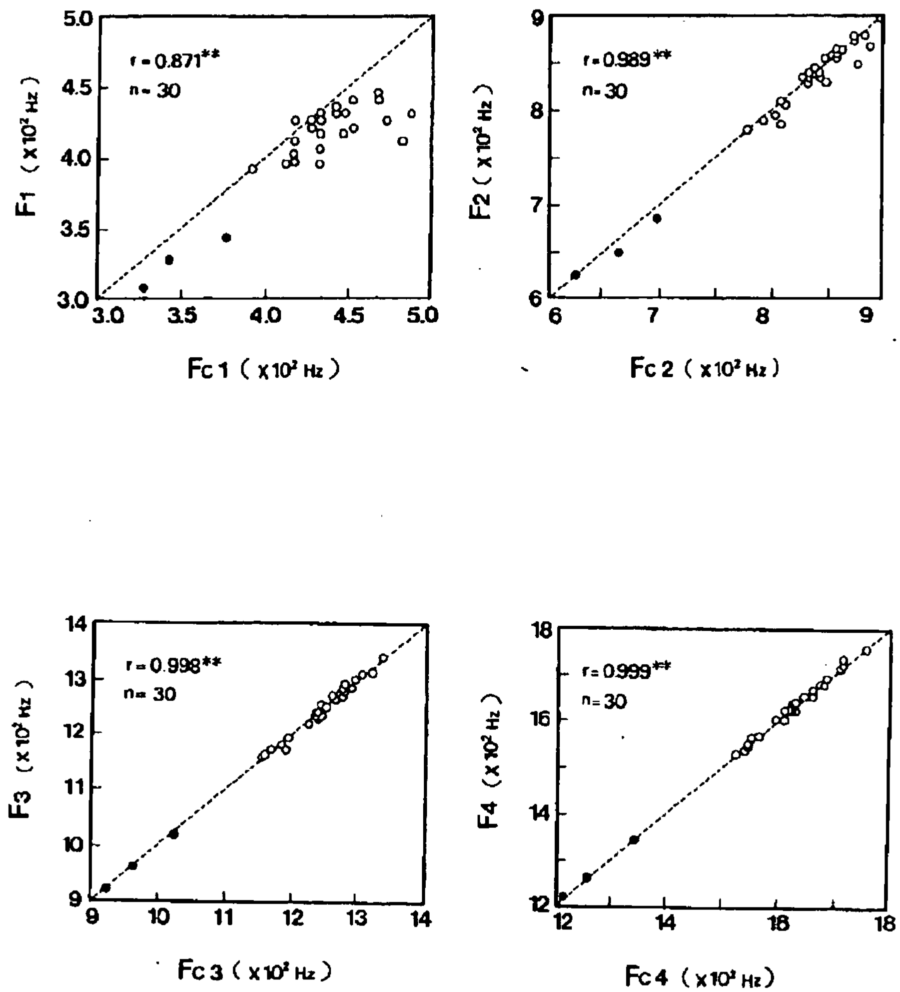
【図1】



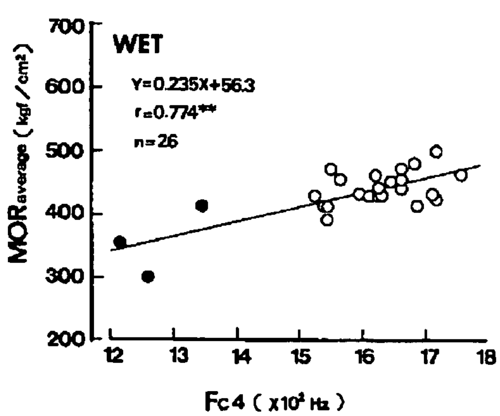
【図2】



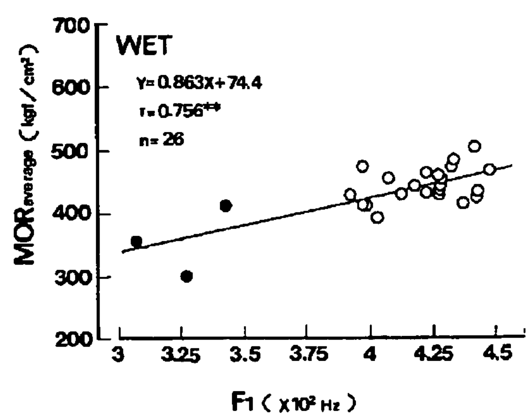
【図3】


r=0.871**
n=30
F1 (x10² Hz)
Fc 1 (x10² Hz)
r=0.989**
n=30
F2 (x10² Hz)
Fc 2 (x10² Hz)
r=0.998**
n=30
F3 (x10² Hz)
Fc 3 (x10² Hz)
r=0.999**
n=30
F4 (x10² Hz)
Fc 4 (x10² Hz)

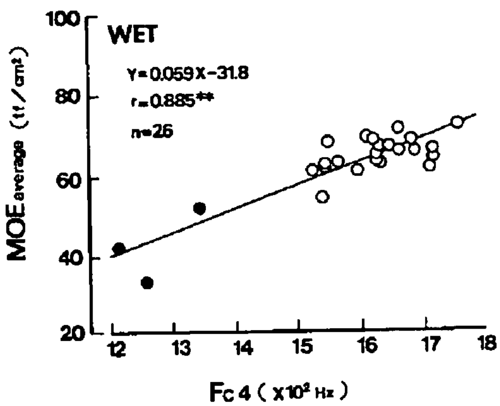
【図4】


WET
Y=0.235X+56.3
r=0.774**
n=26
MORaverage (kgf/cm²)
Fc4 (x10² Hz)

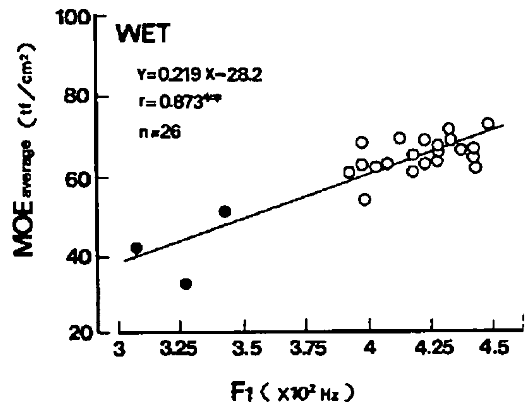
【図5】


WET
Y=0.863X+74.4
r=0.756**
n=26
MORaverage (kgf/cm²)
F1 (x10² Hz)

【図6】



【図7】



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